

CHAPTER 2

Water Quality in Iowa

The Water Cycle

One of the unique things about water on Earth is that it exists in all three phases: solid (ice), liquid, and gas (water vapor). Water continuously moves from place to place on Earth in something called the “water cycle” (see the figure below). As water moves from location to location, it may also change from liquid to solid or gas as it moves through the cycle, and the residence time (or length of time water stays in one of these forms) varies considerably from a few days in the vapor phase to potentially thousands of years in the solid phase.

The water cycle is driven by the energy from the sun, which heats the water and results in evaporation from the surface of the Earth. The major components of the water cycle are explained below:

Components of the Water Cycle

- Precipitation: Water that falls to the surface of the Earth. Can be in the form of rain, snow, hail, or sleet.
- Runoff: Water moving from the land surface to streams, lakes, or oceans.
- Infiltration: Water moving into the ground.
- Subsurface Flow: Water moving through the land to streams, springs, lakes, oceans
- Interception: Precipitation that is caught or “intercepted” on the surface of plants.
- Evapotranspiration: Water that evaporates and transpires from plants.

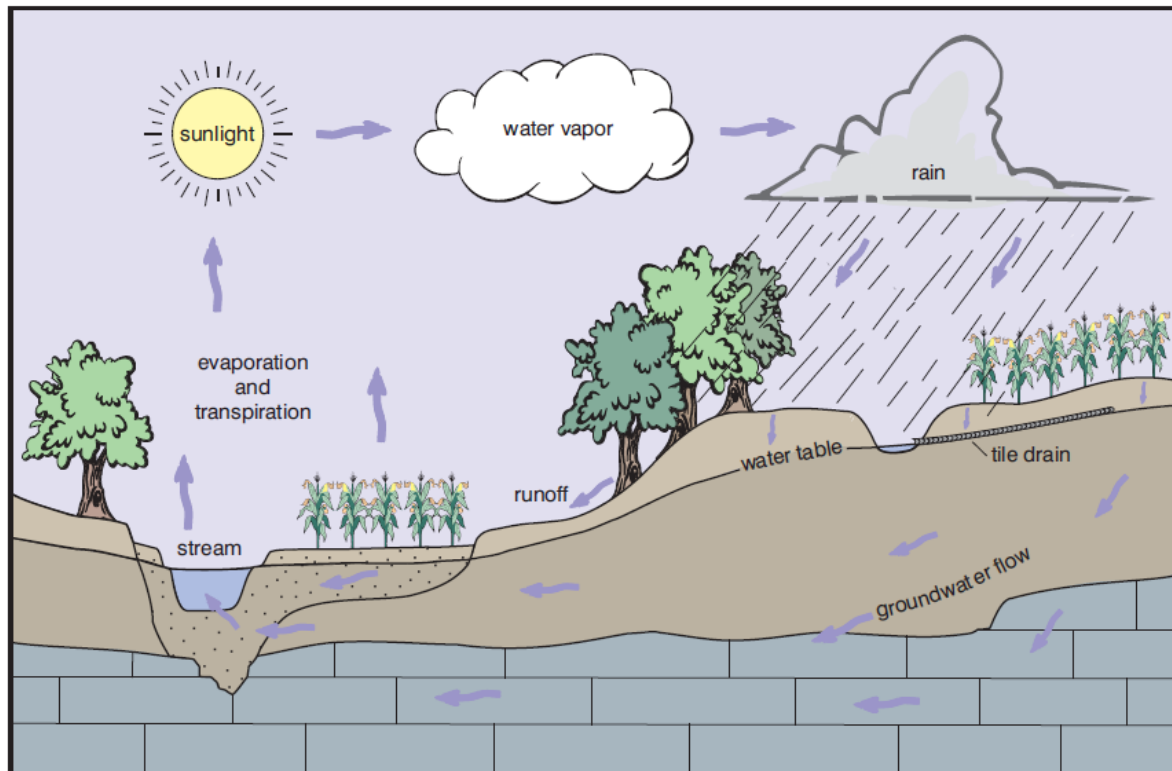
Mechanisms of the Water Cycle

Precipitation falls from the sky as rain and snow and is either intercepted by plants (or other objects) or falls to the ground. Once on the ground, the water can infiltrate into the ground, become part of the snow pack in a glacier, or run off the surface to streams, lakes, or oceans. Water stored in glaciers can remain in solid form for thousands of years before the ice and snow melts resulting in runoff to streams, lakes, or oceans or infiltration to the underlying groundwater. Plants can pull water from the ground and release this water as vapor through evapotranspiration. Rising air currents take the water vapor up into the atmosphere where cooler temperatures cause it to condense into clouds. Air currents move water vapor around the globe eventually forming new clouds and resulting in precipitation again.

Average reservoir residence times	
Reservoir	Average residence time
Antarctica	20,000 years
Oceans	3,200 years
Glaciers	20 to 100 years
Seasonal snow cover	2 to 6 months
Soil moisture	1 to 2 months
Groundwater: shallow	100 to 200 years
Groundwater: deep	10,000 years
Lakes	50 to 100 years
Rivers	2 to 6 months
Atmosphere	9 days
Reference: PhysicalGeography.net	

There are many human activities that can alter the water cycle including construction of dams, removal of groundwater for various purposes (industry, agriculture, and drinking water), removal of forests, urbanization, or other activities that remove or add water to the landscape. Since water quality is closely tied to the water cycle, it is important to understand how changes to the water cycle can have lasting water quality impacts.

The Hydrologic Cycle in Iowa



The Hydrologic Cycle (Iowa's Groundwater Basics: www.igsb.uiowa.edu/gwbasics/ES-6.pdf)

Iowa's Rivers & Streams

Iowa receives an average of 32 inches of precipitation in a typical year, providing ample surface water to nearly 72,000 miles of streams; 125,000 acres of **lakes**, reservoirs, and **ponds**; and 50,500 acres of marshes. During the most recent assessment of water quality in Iowa (2008), 439 of Iowa's waterways were considered impaired (partially supporting or not supporting designated uses; see full description of impairments on the Iowa DNR webpage at <http://www.igsb.uiowa.edu/wqm/WQA/303d.html#2008>). Below the surface, Iowa's **groundwater** is abundant and of relatively high quality.

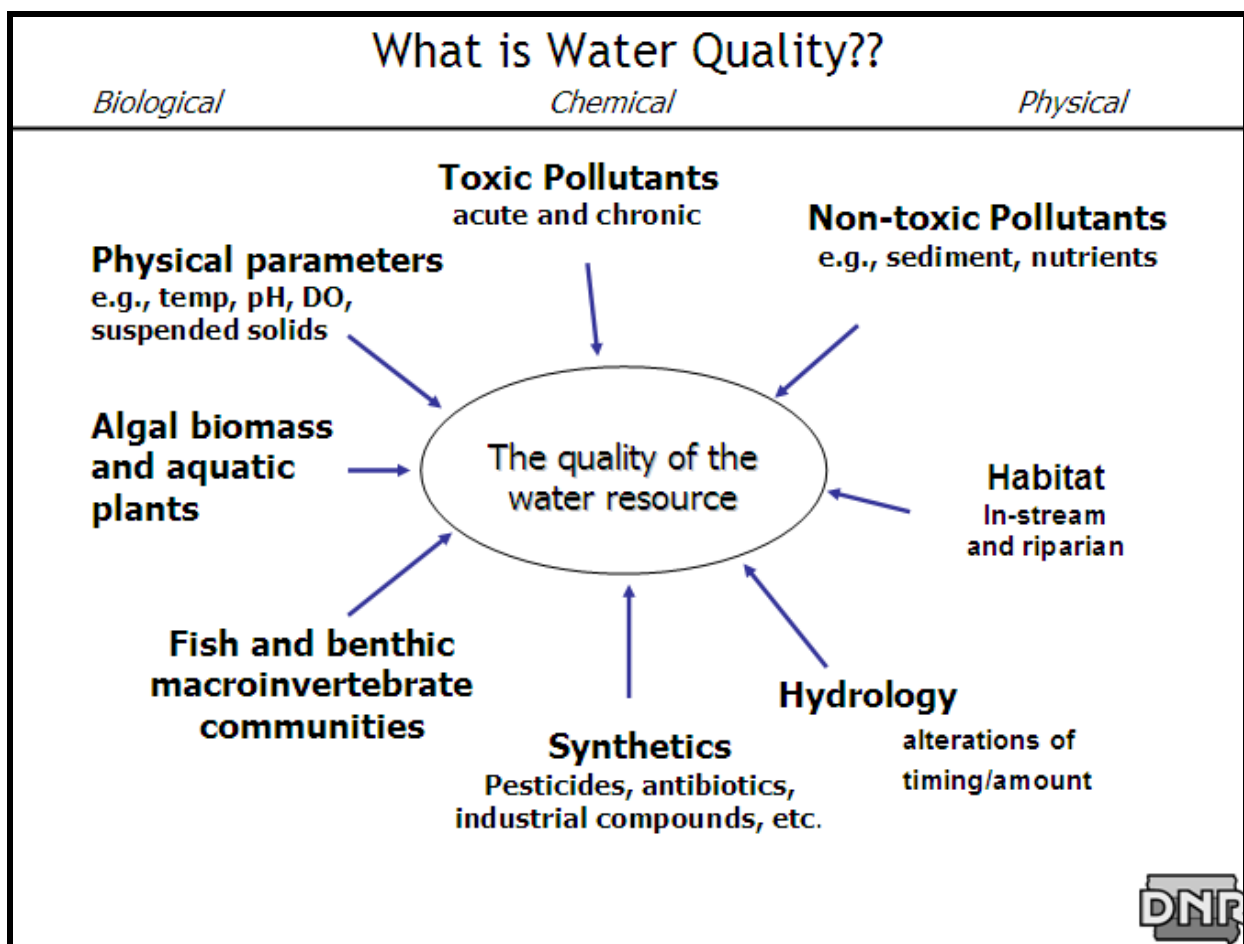
Of the estimated 71,665 stream miles, 26,630 are considered **perennial** (water present all year, often with **baseflow**), 42,957 miles are considered **intermittent** or **ephemeral** streams (water present most of the year or seasonally), and 1,418 miles are classified as drainage ditches. In addition, 660 river miles form the eastern and western borders of Iowa, a distinction that has spawned Iowa's nickname, "Land Between Two Rivers." See Chapter 9 for more on intermittent and perennial streams.

Iowa is very fortunate to have an abundance of water resources. Our surface waters provide many beneficial uses including drinking water, recreation, fish **habitat**, industrial processing, livestock watering, crop irrigation, and use by our many species of wildlife. Clean water ensures that human and ecological health are protected, and the need for costly water treatment is minimized.

Water Quality Monitoring

What is Water Quality?

When IOWATER refers to water quality, we are referring to the collective biological, chemical, and physical health of water (see diagram below). Water quality is more than the amount of pollutant or chemical in streams, rivers, or lakes. Water quality encompasses the life forms that live in the water (fish, invertebrates, plants) and the way the water moves off the landscape. To understand the overall health of a waterbody, it is important to examine all of these factors, rather than just one or two. The IOWATER program provides training in how to collect samples and analyze the water for many of these basic characteristics. For those characteristics that are beyond our training, we provide links to resources and ideas for volunteers on how they may be able to collect this information using local, state, or federal agencies or nongovernmental partners.



Why Monitor Water Quality

Monitoring water quality is the only way that we know what the status of our water is and how this has changed through time (trends in water quality). While simply looking at the water can sometimes be helpful in determining if the stream is muddy or not, it rarely tells us all that we need to know about what is happening within the water body. Many chemicals do not cause visual changes to the water, but can only be detected with tests designed to measure them.

How to Monitor Water Quality

The first step in monitoring water quality is literally the first “step” – into the stream to collect the water for testing. The IOWATER program generally recommends that water be collected from within the stream flow – where the water is well-mixed – rather from the side of the stream. Collecting water from the “middle” of the stream is the best representation of the overall quality of the stream as backwaters or areas close to the bank may be more stagnant or subject to impacts from the banks (soil falling down the bank). To prevent the water quality monitor from stirring up the bottom sediments or dirt, IOWATER protocols will have you move slowly into the stream. Once in the stream (being careful to avoid dangerous high water conditions), face upstream or in the direction where the flow of the stream is coming toward you. Facing upstream ensures that your water sampling will not be affected by sediment that you may have stirred up while entering the stream. With most of the IOWATER kits, you can directly “dip” your test strip or vial directly into the stream for testing. Again, always do this facing upstream and for the length of time specified on the bottle.

The Introductory IOWATER program uses field tests or water quality testing procedures that can be completed at the stream in order to determine the chemical quality of the water. Most of these kits are colorimetric – in other words, they cause a color change on a test strip or in a vial that can be compared against a known or standard value. The precision of a colorimetric field test is generally not as high as the precision of a laboratory test, but it is still a good indicator of the general level of the chemical found in the stream.

Understanding Test Results

Measurement of a chemical in water is generally expressed as the weight or mass of the chemical per volume of water. This is called the “concentration” of the chemical in a water quality sample. For example, when we measure dissolved oxygen in a stream we determine what mass of oxygen (milligrams or mg) is in a standard volume of water (1 liter or L). For a one liter sample of water containing 10 milligrams of dissolved oxygen, this would be expressed as 10 mg/L. Sometimes the concentration values are expressed as parts per thousand, parts per million, or parts per billion which is the mass ratio of the chemical to the mass of the water (this is only true at relatively low concentrations – below 7,000 mg/L). The table below shows the comparison of standard concentration values expressed in “parts per” language. In the case of some chemicals, the IOWATER program does not have a field kit available for use. In these situations, the program submits samples to a laboratory to run the tests on specialized machines. These tests tend to be more expensive than a field kit test and therefore are only used when a field test is not available or when more accurate results are needed than can be provided by a field test.

Testing for chemicals in Iowa’s water requires the ability to detect very small amounts of chemical in the water. However, even though the amount of chemical might be very tiny (parts

per billion), these amounts can also be significant to the aquatic life that inhabit the stream. In addition, what is a significant concentration of one chemical may not be significant for another chemical. For example, negative human health effects occur with concentrations of some pesticides in the parts per billion (ug/L) range, while the human health consequences of nitrate are in the parts per million (mg/L) range.

Concentration Units			
abbreviation	definition	mass ratio description	mass ratio
mg/L	milligrams per liter	parts per million	1:1,000,000
ug/L	micrograms per liter	parts per billion	1:1,000,000,000
ng/L	nanograms per liter	parts per trillion	1:1,000,000,000,000

Road Map for IOWATER Workshops

The IOWATER program is built on the philosophy that volunteers will want to learn the basics of water quality monitoring, but have opportunities to expand their knowledge when the time is right. Each new IOWATER volunteer will enter the program by taking the Introductory IOWATER workshop. This eight-hour workshop will teach you the basics of water quality, water quality monitoring, and how to conduct tests of common chemicals found in Iowa's waters. After you have successfully completed the Introductory IOWATER workshop, you are able to select from a variety of more advanced options. These options include an introductory biological workshop, a workshop on bacteria monitoring, and workshops aimed at more rigorous testing and analysis of water chemistry. Our goal as a program is to help you move through these workshops in a way that best fits your goals. As with any road map, there are many pathways and possibilities to get you to your destination. IOWATER is here to help you pick your destination and navigate the best route for you.

Pollution Sources in Iowa

Iowa's water quality today is different than it was a few decades ago. As recently as the early 1970s, Iowa's rivers were running red with wastes from slaughtering plants, communities were sending untreated sewage downstream, and high **nitrate** levels were plaguing many drinking water sources. With the passage of the landmark Clean Water Act of 1972, improved water treatment helped eliminate some of the most blatant **pollution** sources.

Much of the focus of the Clean Water Act to date has been on **point source pollution**. These pollution sources originate at a "point," such as a factory's wastewater pipe or a community's sewage treatment facility. These sources are monitored through a permit system by the Iowa DNR's Environmental Services Division. These **discharge permits** set the maximum amount of a pollutant that an entity is permitted to release into a water body, and are based on certain limits, or standards, as determined by the U.S. Environmental Protection Agency (EPA) and adopted by Iowa. While addressing point sources of pollution has helped to improve water quality, new challenges have emerged.

The most significant threat to Iowa's surface water today is **nonpoint source pollution**. This pollution does not come from a single point; rather, it comes from an entire watershed. **Runoff** from crop fields can add **sediment**, **nutrients**, and **pesticides** to Iowa's surface waters. Manure spills can contribute ammonia, bacteria, and oxygen-demanding **organic matter**. Runoff from construction sites, lawns, parking lots, and streets can contribute a smorgasbord of pollutants,

including bacteria, heavy metals, nutrients, organic matter, pesticides, and **silt**. Sewage bypasses and overflows from combined **sanitary** and **storm water sewers** plague some communities that have outdated sewer lines or wastewater treatment plants.

Sediment

In Iowa, one of the biggest water quality concerns is soil **erosion**. Soil erosion carries fine particles of dirt, called sediment, to our streams during **runoff events** (heavy rains or spring snow melts). Sediment is also carried into our streams from eroding **stream banks**. The rate of stream bank erosion has increased in many streams as a result of **channelization**. These waterways have been straightened, and plants that anchor the banks have been removed in an attempt to drain areas as quickly as possible. This increases the speed of the water, and with minimal plant cover to retain the stream bank soil, the **streambed** erodes even more. A stream that is eroding more sediment than it is depositing is called a **degrading stream**.

Sediment can be carried by water until it settles to the bottom of a stream or lake (**sedimentation**). A stream that is depositing more sediment than it is eroding is called an **aggrading stream**. A small amount of sedimentation is a natural process; it has always happened and always will. However, too much sediment is harmful to our lakes and streams. As it settles out of the water column, it covers up stream and lake bottoms, and thus harms the **aquatic communities** that live there. Many animals cannot feed and reproduce successfully because sediment clogs gills, smothers eggs, and destroys food supplies and habitat. Soil suspended in the water reduces light penetration, thereby slowing the growth of aquatic plants and reducing **photosynthesis**. This means less food and oxygen is available for aquatic wildlife.

Another way that sediment pollution can harm streams is by changing the types of habitat available. Sediment builds up in the bottom of streams and changes the shape of the streambed by filling in **riffle**, **run**, and **pool** areas. Habitat is lost as sediment fills in the spaces between rocks and other streambed substrates, thus increasing substrate **embeddedness**. As these streams get shallower, they tend to widen, warm, and slow down. This results in reduced **dissolved oxygen** levels in streams (warm water holds less oxygen than cool water) and increased stream bank erosion.

Nutrients

Nutrients, such as **nitrogen** and **phosphorus**, are essential to plant growth. On agricultural fields, they are necessary elements for crop production. In our waters, they contribute to overproduction of **algae**, which can give the water a greenish hue and sometimes a foul odor.

Nutrient enrichment can start a serious chain of events during which the algal population explode (called an **algal bloom**). As they later die, the bacteria that decompose them deplete the water of oxygen, causing a condition called **hypoxia** (low oxygen). This can cause severe problems, even death, for fish and other aquatic animals. Hypoxia, to some extent, occurs within many of our lakes and streams every year, and occurs on a larger scale at the mouth of the Mississippi River in the Gulf of Mexico. We are all truly connected, from the rural Iowa farmer to the Louisiana shrimp boat captain.

Through sound watershed land use practices, runoff of sediment, nutrients and other nonpoint pollutants can be reduced. These practices include best management practices on agricultural

fields, such as the construction of conservation buffers next to our streams. Best management practices also have applications in urban areas. Water runs off lawns, golf courses, streets, and parking lots; many people incorrectly believe that this runoff water is transported to a sewage treatment plant to be treated before entering a stream. Contrary to common belief, however, most of this runoff empties directly into streams, without undergoing any water treatment whatsoever. Overuse of fertilizers, dumping of contaminants, and even excess grass clippings in storm water runoff can contribute to water quality problems.

Current Monitoring Activities

Professional Sites

The Department of Natural Resources monitors approximately 72 stream and river locations around the state on a monthly basis. These sites comprise the “ambient” stream monitoring network for the state of Iowa. These ambient sites tell us the condition of Iowa’s water by selecting monitoring sites that are not targeted at problems, but rather provide the general water quality picture for the state. The mission of the ambient monitoring program, then, is to conduct an on-going assessment of the condition of Iowa’s surface and groundwaters and to report this back to the citizens of Iowa and decision makers so that appropriate information is available to guide policy and resource managers. To meet the mission of the ambient water monitoring program, the following goals were established:

1. Define the condition of Iowa’s water resources
2. Measure changes and identify trends in water quality
3. Provide information for designing abatement, control, and management programs.
4. Characterize existing and emerging issues by type, magnitude, and geographic extent.
5. Provide information to evaluate the effectiveness of natural resource management programs.
6. Report information in useful formats to inform the citizens of Iowa about the quality of their water resources
7. Involve citizens in monitoring to increase their appreciation and understanding of Iowa’s natural water resources

The DNR’s ambient monitoring program focuses on the chemical, physical and biological quality of streams. The 72 stream sites are monitored monthly for basic physical properties (dissolved oxygen, temperature, stream flow, and pH) along with nutrients (nitrogen and phosphorus) and basic chemical constituents such as chloride, sulfate, silica, total suspended solids, total dissolved solids, and others.

IOWATER Sites

With more than 72,000 miles of stream in Iowa, it is quite a task to monitor and assess all of the waters of the state. IOWATER volunteers are key to collecting data on stream sites that would rarely, if ever, have professional monitoring on them. The number of volunteer monitoring sites continues to grow each year, but the need for additional data is still great. Since water quality does not remain the same from month to month or year to year, the ongoing monitoring of IOWATER volunteers will help to fill in a picture of Iowa’s water quality for generations to come.

